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Calculation of requirements for Air Conditioning Systems on a typical floor of Menara Suara Merdeka

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Abstract: This research discusses the heat load calculation in the air conditioning system in buildings, which can determine the energy consumption value. Air conditioning is the treatment of air to regulate temperature, humidity, cleanliness and distribution simultaneously to achieve the comfortable conditions required by people in a room. This research aims to design air conditioning at Menara Suara Merdeka Semarang, which has a typical floor to create comfortable conditions in the entire room. The cooling load calculated from a simulation from different factors between the highest and lowest TE ° on the 9th and 10th floors of the Menara Suara Merdeka Semarang building as a floor represents the overall condition of this building. Based on the calculations that have been done, it is found that the energy load is 7.35605 Kcal x 1.163 = 8.5550 Watt (per m³). The following calculation results show that the air conditioning application for this type of room is to install 8 Fan Coil Units (FCUs), each with a capacity of 8 Pk.

Keywords: Air Conditioning, Cooling Load, Building

1. INTRODUCTION

To create comfortable conditions for the body, humans try to make a building that can protect against extreme climates, for example, hot air and sunburn or freezing air. The air conditioning that we know today in every room in the Building is Air Conditioning (AC). AC is a tool that functions to condition the air. It can be said that AC is a device that serves as an air conditioner and air regulator. Air conditioning in the room is intended to obtain the desired air temperature (cool or cold) and is comfortable for the body (Abdurrachman, 2018). Air conditioning usage also affects how green the building is (Almeida et al., 2020) (Lee et al., 2019).

This study examines and analyzes the calculation steps for an air conditioning system following the building's situation and condition with a typical floor, precisely at the Menara Suara Merdeka Semarang building. One of the high-rise buildings in the city of Semarang is the Menara Suara Merdeka Building, and this building is located on Jalan Pandanaran Semarang, which is a building belonging to the Suara Merdeka Group which functions as an office rent building. The 15-storey building with two basements consists of an entrance area, an office area, a parking area and a management office area. One of the skyscrapers in Semarang has a modern style, which is visible with a minimal facade in ornamentation and the use of fabricated materials dominated by glass. Stop-sol glass and reflective glass reduce the sun's heat transfer entering the room in modern buildings in the tropics. The building, which has a south-oriented façade, is dominated by Stopsol glass in the east and reflective glass on the south, west and north sides. The majority of the rooms in this building function as rental offices that ensure users' comfort is the main requirement. Thus, the room needs a proper air conditioning calculation to provide comfort (O'Brien et al., 2011) (Wesołowska & Laska, 2018).

In this connection, several things must be known, such as when and where the peak load occurs in the air conditioning system itself. A detailed calculation analysis is needed to obtain an efficient operation of the air conditioning system without sacrificing the room's comfort and environment to bring energy and economic efficiency by optimizing the air conditioning system's capacity as needed (Rock, 2018). Air conditioning regulates air conditions that include temperature, humidity, air quality, and circulation simultaneously to achieve the occupants' comfortable conditions (McQuiston et al., 2005). Air conditioning must control the desired air temperature for each time. In principle, this conditioning system's working process involves adding or removing a certain amount of heat from the conditioned place.

The air conditioning of a room is usually determined by (1) the amount of humid air be supplied and (2) the condition of the supply air required to remove a certain amount of energy and water from the room (Ashrae Standard, 2001). An air conditioning system is composed of components and equipment arranged in sequence to condition the air, transport it to the conditioned space, and control the indoor environmental parameters of a specific space within required limits (Wang, 2001). Most air conditioning systems perform the following functions: 1. Provide the cooling and heating energy required 2. Condition the supply air, that is, heat or cold, humidify or dehumidify, clean and purify, and attenuate any objectionable noise produced by the HVAC & R equipment 3. Distribute the conditioned air, containing sufficient outdoor air, to the conditioned space 4. Control and maintain the indoor environmental parameters – such as temperature, humidity, cleanliness, air movement, sound level, and the pressure differential between the conditioned space and surroundings — within predetermined limits

2. METHODOLOGY

The first stage is to search for literature related to AC design. Research remained data collection such as the condition of the 10th floor as an empty floor and the condition of the 9th floor as an occupied floor. The last stage is processing the data that has been made where the data can be determined the cooling load per room, which is then totalled to select the right cooling machine.

3. FINDING AND DISCUSSION

Calculation of Heat Load in Building Conditioning Systems

This calculation is done to determine the energy consumption required to condition the room air with the ratio of the room on the 10th floor that has not been used and the room on the 9th floor that has been fully used. On the 10th floor, the adequate temperature conditions and relative humidity in the field are obtained as follows:

Table 1. Room Temperature and Humidity at 10th floor

Time	**08.00**	**09.00**	**10.00**	**11.00**	**12.00**	**13.00**	**14.00**	**15.00**	**16.00**
ETºC	29.6	30.9	31.5	31.2	31.3	31.3	30.6	30.6	30.4
Hum	63	61.2	59.3	61.7	61.7	66.9	61.7	62.7	63.5

If the highest TEº taken is at 13.00, namely 31.3ºC with RH 66.9%. TEº 31.3ºC in a saturated state contains 32.080 grams of water, so:

RH 66.9% = 66.9% x 32.080 = 21.462 grams of water.

On the 9th floor, the following field conditions are obtained:

Table 2. Room Temperature and Humidity at 9th floor

Time	08.00	09.00	10.00	11.00	12.00	13.00	14.00	15.00	16.00
ETºC	28.56	29.16	27.61	25.37	23.71	25.32	26.2	27.58	23.52
Hum	58.62	49.5	51.25	53.75	55.5	53.5	53.37	51.42	57

To take the lowest TEº is at 16.00 which is 23.52ºC with RH 57%. TEº 23.52ºC in a saturated state contains 21.810 grams of water, so:

RH 57% = 57% x 21,810 = 12,432 grams of water.

Thus, the water to be evaporated = 21.462 - 12.432 = 9.03 grams of water.

Provided that the heat needed to evaporate 1 gram of water is 0.61 K cal, then:

To evaporate 9.03 grams of water, you need calories/energy of: 0.61 K cal x 9.03 = 5.5083 K cal ……(a)

1 m³ of dry air 31.3 ºC to 23.52 ºC there is a difference of 7.78 ºC.

The specific heat of dry air = 0.2375 K cal, so to dry the air with a temperature difference of 7.78 ºC it takes calories/energy of:

7.78 x 0.2375 = 1.84775 K cal ………(b)

So that to cool 1 m³ of air from 31.3ºC with RH 66.9% to 23.52ºC with RH 57%, it takes heat of:

(equation 1)

(a) + (b) = 5.5083 + 1.84775 = 7.35605 K cal

To convert the energy / calorie value needed into Watts, then: Convert 1 K cal = 1.163 Watt, so that 7.35605 K cal when converted into Watt will be worth: 7.35605 K cal x 1.163 = 8.5550 Watt (per m³).

Calculation of Room Cooling Energy Needs

Based on Lippsmeier's research and the research of the LPMB PU Foundation regarding the distribution of comfortable temperatures for Indonesians, the temperature needed to be able to do activities properly is at the optimal comfortable temperature (22.8 ° C - 25.8 ° C with 70% humidity). It indicates that the condition of the 10th floor of Menara Suara Merdeka is not involved in the optimal comfort criteria (Lippsmeier, 1997). Hence, the room requires artificial air conditioning such as AC with proper calculation as follow:

(equation 2)

Needs of BTU = (WxHxIxLxE) / 60

BTU : British Thermal Unit (unit of AC requirement) W: Length of room (in feet)

H : Height (in feet)

I : Value 10 if the room is insulated (on the lower floor, or coincide with another room). Score 18 if the room is uninsulated (upstairs).

L : Width (in feet)

E : Value 16 if the longest wall faces north; score 17 if facing east; Score 18 if facing south; and a value of 20 if facing west.

Needs of BTU = 541.399,27 BTU

Known,

AC ½ PK = ± 5,000 BTU / h

AC ¾ PK = ± 7,000 BTU / h

AC 1 PK = ± 9,000 BTU / h

AC 1½ PK = ± 12,000 BTU / h

AC 2 PK = ± 18,000 BTU / h

1 Pk = 735.5 watts / hour

So it can be assumed that the special energy requirements for cooling the room are,

(equation 3)

Energy = BTU / 9,000 x energy 1Pk

= 541,399.27 / 9,000 x 735.5

= 44,244.35 Watt / hour

With an energy requirement of 44,244.35 Watt / hour, the air conditioning application for this type of room is to install 8 Fan Coil Units (FCUs), each with a capacity of 8 Pk.

8 FCU @ 8 Pk @ 735,5 Watt/jam 47.072Watt Jam

4. CONCLUSION

In the conditions above, an attempt to cool 1 m³ of air from 31.3 ° C with RH 66.9% to 23.52 ° C with RH 57% requires a heat of 7.35605 K cal. If the energy/calorie value needed is converted into Watts, the value is 8.5550 Watt (per m³). The special energy requirement for cooling the room is 44,244.35 Watt/hour. With an energy requirement of 44,244.35 Watt/hour, the air conditioning application for this type of room is to install 8 Fan Coil Units (FCUs), each with a capacity of 8 Pk.

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